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Evaluation of L-804 Elevated Runway Guard Light Fixtures

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16. Abstract

The number of inadvertent runway incursions has grown during recent years, increasing the importance of protective visual guidance systems for incursion prevention. One such visual system is the L-804 elevated runway guard light fixture. Also known as a wig-wag light, these fixtures contain two alternately flashing yellow lights and are used to help identify runway holding positions to pilots. Pilots, however, have indicated that the light intensity (600 candelas minimum average intensity) and flash rate (average of 35 flashes per minute per lamp) of the L-804s are inadequate.

The L-804s were examined under day and night visual flight rules (VFR) and instrument flight rules (IFR) conditions from various distances and angles. Particular attention was paid to performance characteristics such as intensity, flash rate, vertical and horizontal aiming angle, lamp separation, and the usefulness of providing a hood over each lamp.

As a result of the evaluation it was determined that the L-804 specifications needed to be modified. Flash rate should be increased to 45 to 50 flashes per minute per lamp. The light intensity of the Mode 1 (constant current) L-804 when energized at 6.6 amps and tested with one lamp in the steady burning mode and the other lamp masked out should be 4100 candelas. The light intensity of the Mode 2 (constant voltage) L-804 when energized at 120 volts and similarly tested should be 940 candelas.

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This Technical Note presents a discussion of L-804s designed to current specifications as well as recently modified L-804s and describes the Federal Aviation Administration Technical Center's evaluation of these fixtures. In addition, recommendations for changes to Advisory Circular 150/5345-46, Specifications for Runway and Taxiway Lighting Fixtures, are provided to improve the L-804s.

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The recently modified L-804s containing higher wattage lamps were field tested. These tests included both a pilot evaluation as well as photometric testing. As a result, it was determined that the intensity levels and flash rates of the modified L-804s are acceptable.

INTRODUCTION

BACKGROUND.

The number of inadvertent runway incursions has grown during recent years, increasing the importance of protective visual guidance systems for incursion prevention. One such visual system is the L-804 elevated runway guard light fixture.

Pilots have expressed concerns that the light intensity and flash rate of currently approved L-804s are inadequate, especially when the units are operated on the lower intensity steps of a constant current regulator. In response to these concerns, the Visual Guidance Section of the Airport Technology Research and Development Branch, AAR-410, conducted an evaluation of the L-804 fixtures.

PURPOSE.

The purpose of this project was to investigate identified operational problems with L-804s designed to current specifications, evaluate recently modified L-804s, and recommend changes to Advisory Circular, 150/5345-46, Specifications for Runway and Taxiway Lighting Fixtures, to improve the L-804s. This project was initiated in response to a request from the Federal Aviation Administration (FAA) Office of Airport Safety and Standards, Engineering and Specifications Division (AAS-200).

OBJECTIVES.

This effort was directed specifically toward evaluating the performance of L-804s designed to current specifications, the recently modified L-804s, and to recommend modifications to Advisory Circular 150/5345-46, Specifications for Runway and Taxiway Light Fixtures, to improve the L-804s.

EQUIPMENT DESCRIPTION

The L-804 elevated runway guard light fixture is a dual lamp unit that is used to help identify runway holding positions. One L-804 was installed adjacent to the runway hold line on each side of the taxiway at a standard height of 30 inches. Each L-804 contained two alternately flashing yellow lights (figure 1). Advisory Circular 150/5345-46 details the performance requirements for L-804 units. The current advisory circular mandates a minimum average intensity of 600 candelas in yellow with a horizontal and vertical beam spread of ±8 degrees. L-804s are produced in two variations referred to as Mode 1 and Mode 2. Mode 1 units operate on a constant current 6.6 amp circuit and Mode 2 units operate on constant voltage circuits. Each light in the L-804 fixture is specified to be illuminated 50 to 60 times per minute with the illuminated period of each flash to be not less than one-half nor more than two-thirds of the total cycle. The fixtures are specified to be aimed at any vertical angle from 0 to 20 degrees in elevation.

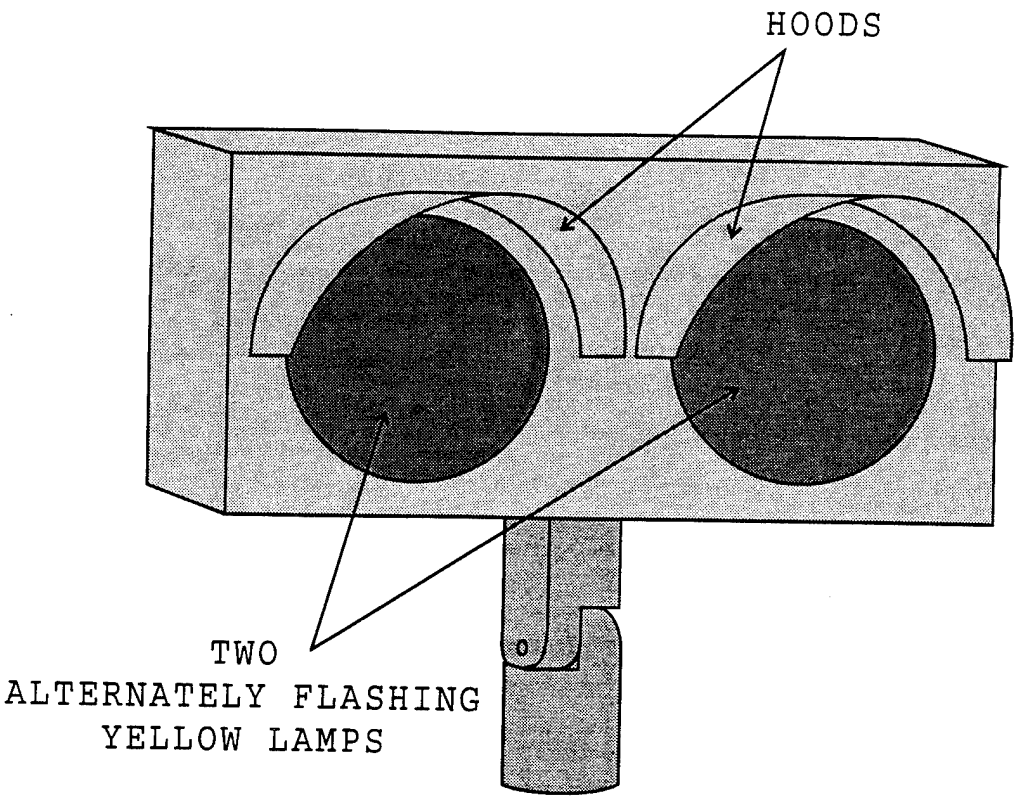

FIGURE 1. L-804 ELEVATED RUNWAY GUARD LIGHT FIXTURE

This evaluation consisted of field testing the effectiveness of four different L-804 fixtures. The four evaluation units were provided by two manufacturers, including

1. A Mode 1, 6.6-amp current driven L-804 unit with 45-watt lamps.

2. A Mode 2, 120-volt L-804 unit with 30-watt lamps.

3. A Mode 1, 6.6-amp current driven L-804 unit employing an optional constant output (intensity) device and 115-watt lamps. This newly designed unit also included a potentiometer for adjusting flash rate.

4. A newly designed Mode 2, 120-volt L-804 unit using 116-watt lamps.

INITIAL EVALUATION

Initial testing consisted of several evaluations of L-804 performance under varying conditions of sunlight and visibility. The units were placed on opposite sides of taxiway kilo at the Atlantic City International Airport (ACY) to provide a comparison in performance (figure 2). Each unit was positioned 20 feet from the edge of the taxiway and approximately 60 feet from the centerline. Of particular interest was the comparison of flash rate, intensity, and rise-and-fall

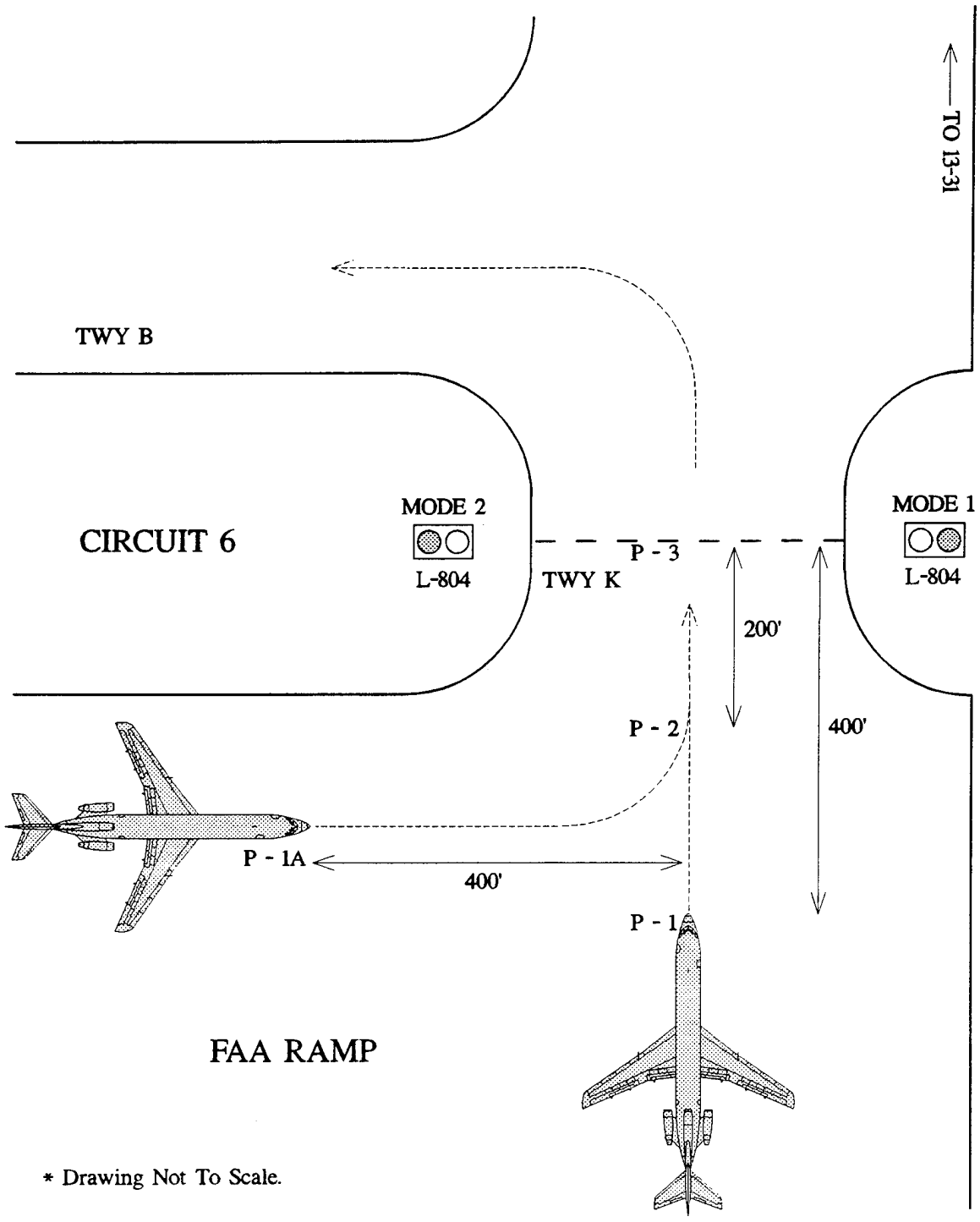

FIGURE 2. L-804 OBSERVATION POSITIONS

times for the Mode 1 and Mode 2 lamps. The current driven (Mode 1) units were set up and operated in series with the ACY 6.6-amp taxiway circuit number 6. The Mode 1 unit was initially evaluated with the constant intensity feature bypassed and, subsequently, with the feature operating. The voltage driven (Mode 2) unit was powered by a portable 120-volt generator. Units were viewed from a wide range of angles and distances. In addition, the L-804 units were observed from heights ranging up to 23 feet above the taxiway surface by using an air stairs vehicle. This procedure was used to help establish optimal vertical angle settings for pilot eye heights in aircraft as large as a DC-10.

During the daylight evaluations, the L-804 units were operated throughout the range of intensity settings in an effort to determine whether performance was satisfactory. The L-804s were evaluated from various viewing angles and from distances of up to 600 feet and in visibilities ranging from 600-feet runway visual range (RVR) to 10 miles. Elevation angles were set, and unit effectiveness examined at 5, 10, and 15 degrees for each unit. The 115-watt and 116-watt lamp units when energized at full intensity were deemed to be acceptable for daylight operations. However, when the Mode 1, 45-watt lamp unit and the Mode 2, 30-watt lamp unit were energized at full intensities, they were too dim to provide effective identification of the runway holding position.

During the daylight evaluation conducted in 600-foot RVR conditions, only the Mode 1, 115-watt lamp L-804 and the Mode 2, 116-watt lamp L-804 were examined. Initially, basic observations of comparative and absolute effectiveness of these two units were made from approach positions along taxiway kilo's extended centerline at ranges of 500 to 100 feet (similar to the path from position P-1 to P-3 as shown in figure 2). At 500 feet, both units were visible but were not eye-catching until the evaluation team was positioned approximately 300 feet from the units. At 200 feet, both units provided excellent visual guidance.

Subsequently, approaches to the light units were made along a path perpendicular to taxiway kilo's extended centerline and intersecting it at a distance of 200 feet from the holding position (similar to the path from position P-1A to P-2 as shown in figure 2). Both units were identified at a distance of approximately 220 feet from the extended taxiway centerline and were judged to be adequate for positively defining the edges of the runway holding position.

Additional evaluations were conducted during hours of darkness. Since the L-804 units containing the 30- and 45-watt lamps had previously been judged to be inadequate based on the daylight evaluation, the nighttime evaluation included only the units containing the 115- and 116-watt lamps. These L-804 units were operated throughout the full range of intensity settings in an effort to determine whether performance was satisfactory. Viewing angles and distances were varied, and the L-804's were observed in visibility ranges of ¾ to 10 miles. At the highest intensity setting (6.6 amps), the brightness of the Mode 1 unit was deemed to be excessive for night operation since the lamps tended to "bloom" and filament cycles overlapped. The Mode 2 unit was operated at three intensity settings with the aid of a variac to vary the input voltage. Selected settings included 120 volts (100% intensity), 85 volts (30% intensity), and 60 volts (10% intensity). This unit, when operated at the highest intensity setting (120 volts), was also

judged to be too bright. A decision was made to conduct an additional pilot evaluation of these two units to help establish the optimum nighttime intensity settings.

Lamp separation distances of 18 and 24 inches were evaluated to determine whether increasing this distance from the original 12 inches would improve effectiveness by making the two lamps appear more distinct or separate when viewed from long distances. One of the manufacturers had originally provided an extra lamp fitted with long flexible leads that allowed the distance between lamps to be varied. After experimenting with these variations, it was determined that although increasing the separation distance did in fact make the lamps appear more separate, this did not make the L-804s appear anymore conspicuous. In fact, any benefits gained from increasing the lamp separation distance from the original 12 inches would probably be offset by potential wind load/jet blast problems caused by the associated increase in the size of the L-804 housing assembly.

In an attempt to enhance the daytime contrast between the L-804 yellow lights and the yellow face of the housing assembly, the concept of changing the color of the L-804 face from yellow to black was investigated. This was accomplished by using pieces of black cardboard to cover the L-804 face. In addition, an enlarged face extending three inches beyond the normal face surface was taped in place for evaluation. These ideas proved to be somewhat effective in enhancing contrast, however, an enlarged face is not recommended because of potential wind load/jet blast problems.

In an effort to assess the effects of the hood devices on lamp effectiveness, the various L-804 units were operated with and without hoods. It soon became obvious that the hoods greatly increased the effectiveness of the L-804 units during both day and night operations. During the day, the hoods reduced the sun's reflection on the lamp in the off cycle so that the lamp appeared to be completely off. At night, the hoods also improved performance by making the lamps appear more distinct or separate when viewed at shallow angles. Hood dimensions are shown in figure 3.

As initial testing of the L-804 units progressed, it became obvious that the two units that contained the 30- and 45-watt lamps simply lacked the necessary light intensity to be effective visual aids. The L-804 units containing the 115- and 116-watt lamps were both judged to be much more effective, although each of these two units has its own advantage. The Mode 2, 120-volt unit exhibited a very sharp lamp rise and fall time, however the Mode 1, 6.6-amp unit caught your attention at a farther distance during the testing conducted in 600-foot RVR conditions. This can be explained by referring to figures 4-7 which show the results of the L-804 photometric testing that was accomplished by the Naval Air Warfare Center photometric laboratory at Lakehurst, New Jersey. As shown in figures 4 and 5, the Mode 1 L-804 constant current unit when energized at 6.6 amps and tested with one lamp in the steady burning mode and the other lamp masked out had an intensity level of just over 4000 candelas. As shown in figures 6 and 7, the Mode 2 L-804 voltage unit when energized at 120 volts and tested with one lamp in the steady burning mode and the other lamp masked out had an intensity level of approximately 940 candelas. Since these results show that the Mode 1 unit produced

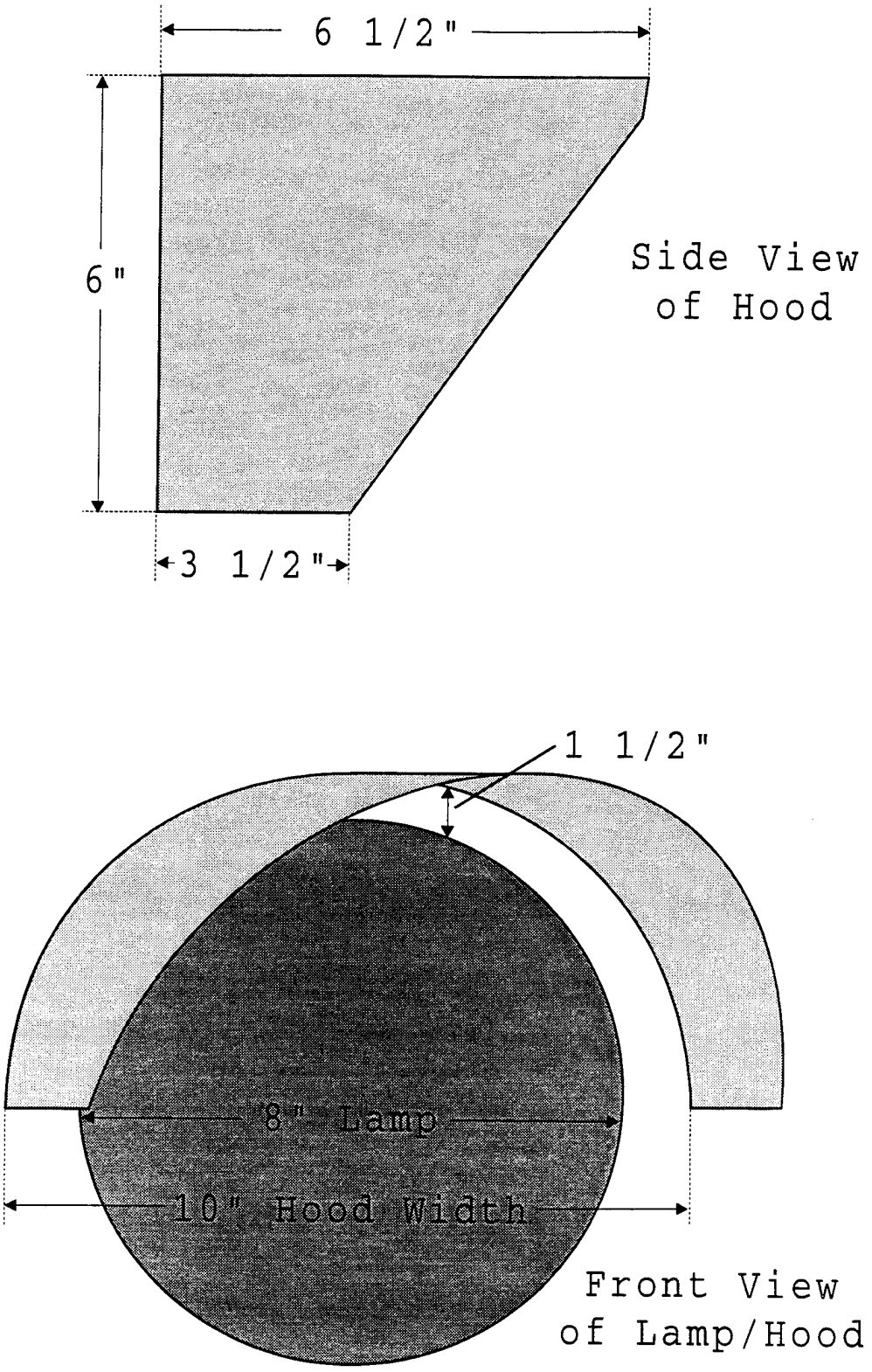

FIGURE 3. L-804 HOOD DIMENSIONS

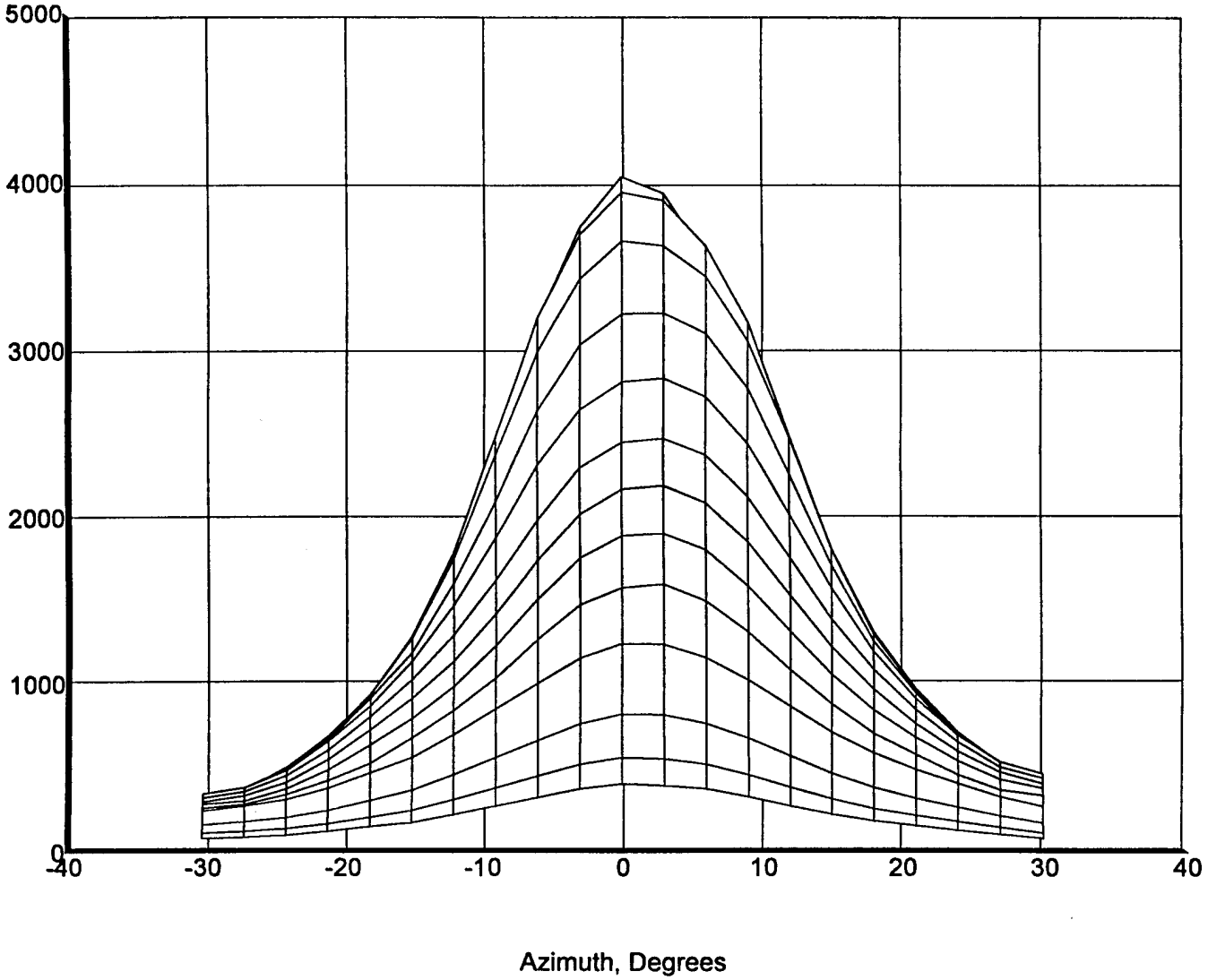

FIGURE 4. MODE 1 L-804 CANDELA PLOT

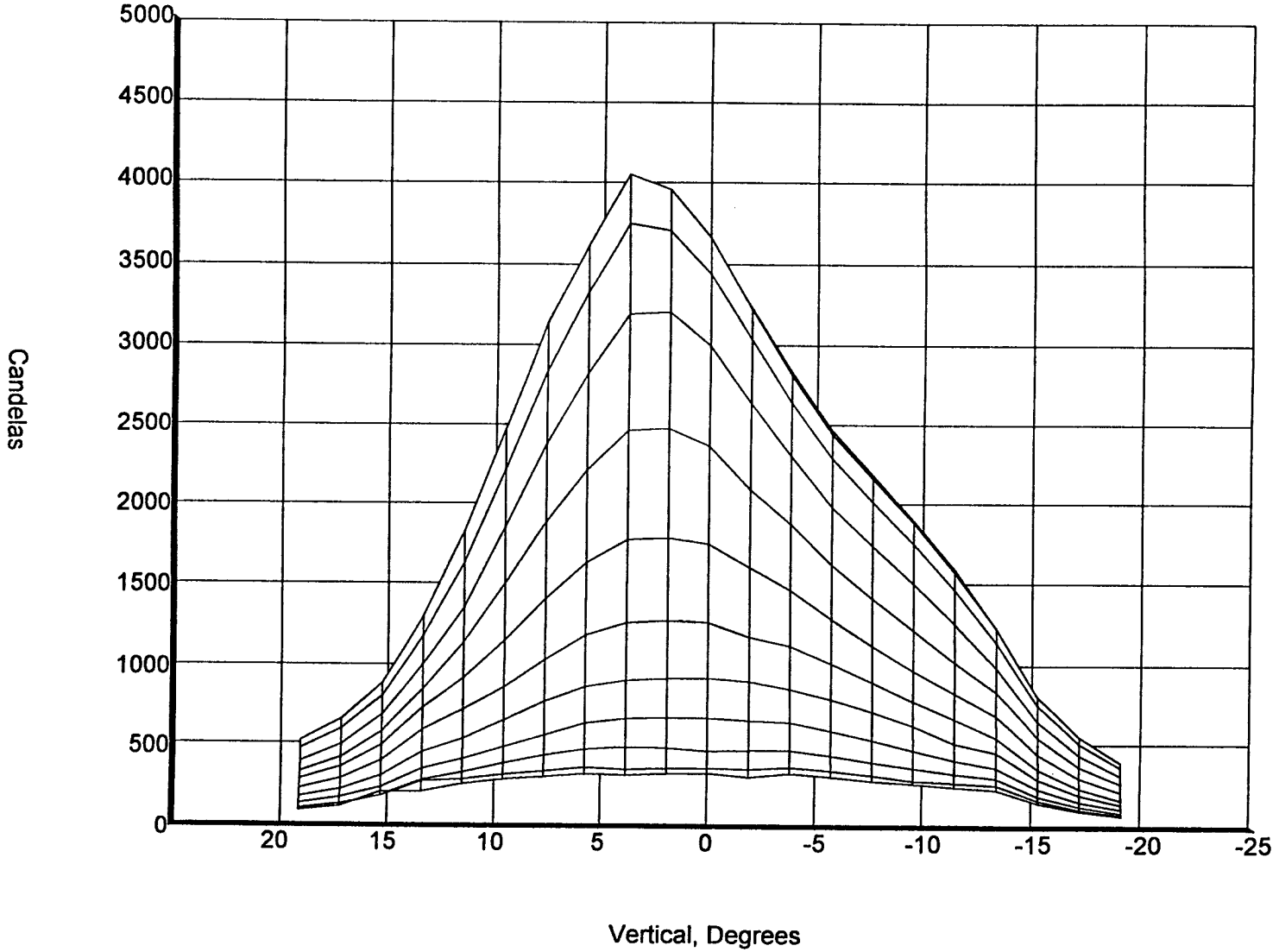

FIGURE 5. MODE 1 L-804 CANDELA PLOT

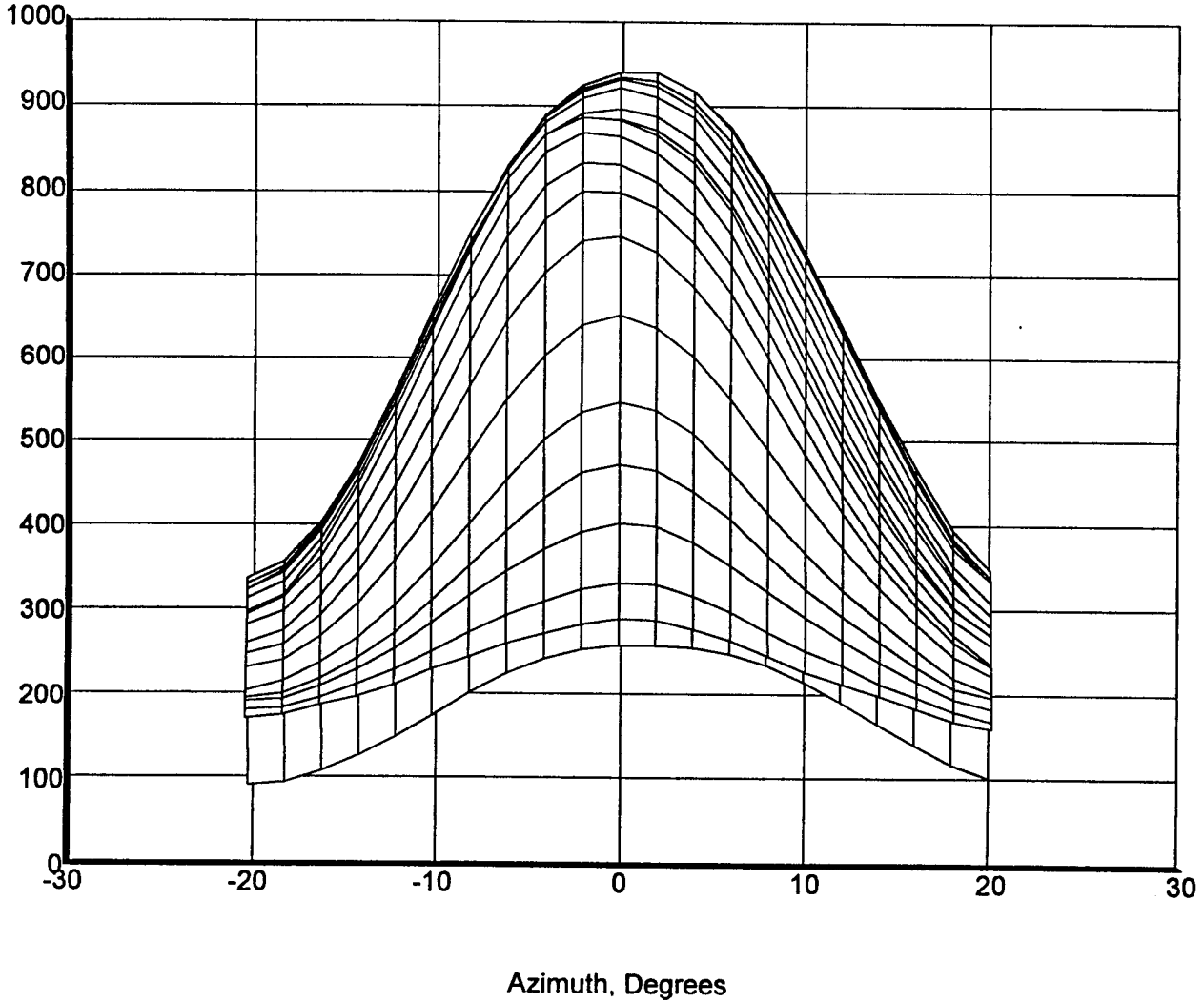

FIGURE 6. MODE 2 L-804 CANDELA PLOT

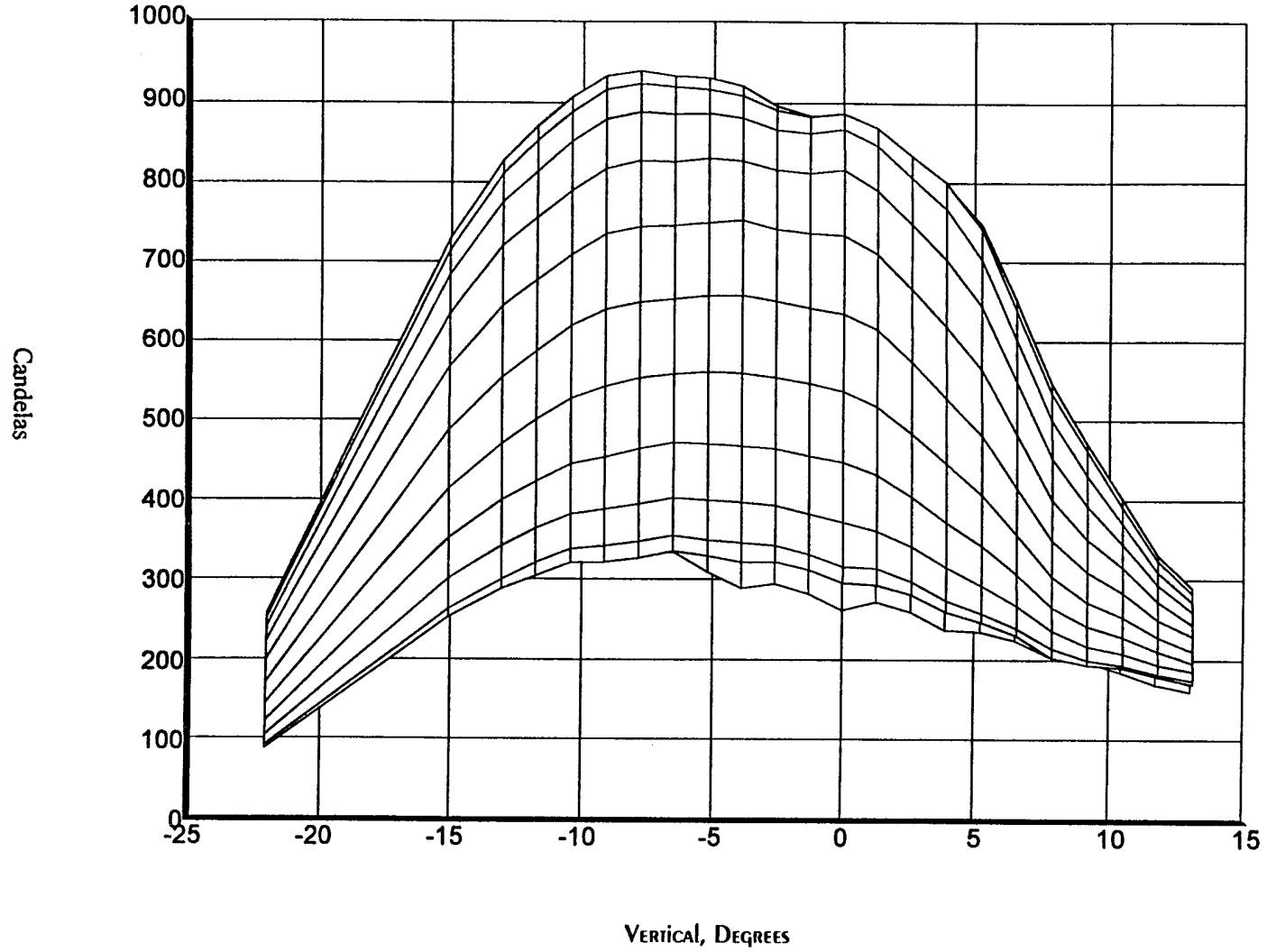

FIGURE 7. MODE 2 L-804 CANDELA PLOT

approximately four times as many candelas as the Mode 2 unit, it stands to reason that the Mode 1 unit should be noticed at a farther distance in the 600-foot RVR weather conditions.

As a result of the initial evaluation, it was decided to proceed with a subject pilot evaluation of the two more promising units containing the 115- and 116-watt lamps.

SUBJECT PILOT EVALUATION

During this phase of the evaluation, the L-804 units containing the 115- and 116-watt lamps were viewed during VFR nighttime conditions from an FAA Boeing 727. Prior to observing the L-804s, FAA subject pilots were given a briefing regarding the purpose of the evaluation, the configuration of the units, and the operational procedures to be followed. The units were set up on opposite sides of taxiway kilo to provide performance comparisons. Pilots were asked to evaluate the effectiveness of the units at various intensity settings and flash rates with the constant intensity device by-passed. The intensity settings for the current-driven unit were 6.6, 5.2, and 4.1 amps. Selected settings for the voltage unit included 120 volts (100% intensity), 85 volts (30% intensity), and 60 volts (10% intensity). Only one of the two units examined from the aircraft had an adjustable flash rate device which was set at 60, 48, or 30 flashes per minute per lamp. Taxiing approaches were made to the two L-804 units using two aircraft paths, as depicted in figure 2. These paths included stops at positions P-1, P-2, and P-3 or P-1A, P-2, and P-3. Pilots were asked to complete a standard evaluation questionnaire, as shown in figure 8, immediately following each test session.

RESULTS/PILOTS COMMENTS

A total of nine pilots participated in the subject pilot evaluation. Pilot responses regarding the intensity and flash rate of the units are tabulated in figure 8. Replies to the questions relating to intensity indicate a distinct preference for the step 4 setting on the Mode 1 unit (5.2 amps). All nine pilots indicated that the step 5 setting (6.6 amps) was too bright, and six of the nine indicated that the step 3 setting (4.1 amps) was too dim. Regarding the Mode 2 unit, eight of the nine pilots indicated that they preferred the 85-volt setting. Most of the pilots (6 of 9) expressed the opinion that the 120-volt setting was too bright, and a majority (5 of 9) stated that the 60-volt setting was too dim.

Replies to questions relating to flash rate indicate a preference for the 48 flashes per minute per lamp setting. Most of the pilots (7 of 9) indicated that 60 flashes per minute per lamp was too fast and 30 flashes per minute per lamp was too slow. The majority of pilots (6 of 9) preferred 48 flashes per minute per lamp. Based on these results, it is recommended that the L-804 flash rate be specified at 45 to 50 flashes per minute per lamp instead of the presently specified rate of 50 to 60 flashes per minute per lamp.

NAME 9 TOTAL DAY ___ or NIGHT X VISIBILITY VFR

1. How would you rate the intensity of the wig-wags under the observed conditions?

a) Mode 1 Unit (Right Side of T/W K) at 6.6 amps

Too Bright 9 Correct 0 Too Dim 0

b) Mode 2 Unit (Left Side of T/W K) at 120 volts

Too Bright 6 Correct 3 Too Dim 0

c) Mode 1 Unit (Right Side of T/W K) at 5.2 amps

Too Bright 2 Correct 7 Too Dim 0

d) Mode 2 Unit (Left Side of T/W K) at 85 volts

Too Bright 1 Correct 8 Too Dim 0

e) Mode 1 Unit (Right Side of T/W K) at 4.1 amps

Too Bright 1 Correct 2 Too Dim 6

f) Mode 2 Unit (Left Side of T/W K) at 60 volts

Too Bright 0 Correct 4 Too Dim 5

FIGURE 8. L-804 PILOT QUESTIONNAIRE SUMMARY SHEET

2. How would you rate the flash rate of the wig-wags under the observed conditions?

a) Mode 1 Unit (Right Side of T/W K) at 60 flash/min

Too Fast 7 Correct 2 Too Slow 0

b) Mode 1 Unit (Right Side of T/W K) at 48 flash/min

Too Fast 1 Correct 6 Too Slow 2

c) Mode 1 Unit (Right Side of T/W K) at 30 flash/min

Too Fast 0 Correct 2 Too Slow 7

Comments _____

_____

_____

_____

THANK YOU

FIGURE 8. L-804 PILOT QUESTIONNAIRE SUMMARY SHEET (CONTINUED)

The following pilot comments were recorded during the evaluation. While not necessarily direct quotes, they reflect the general nature of the original comments.

INTENSITY EVALUATION.

- The L-804 units make it difficult to clear for traffic on final approach. They are too bright and might make you miss the traffic. (Mode 1 at 6.6 amps and Mode 2 at 120 volts)

- The lights are quite dim and could be washed out in an intense environment. (Mode 1 at 4.1 amps and Mode 2 at 60 volts)

- The Mode 2 voltage unit was favored from the pilot's and copilot's view. It has a crisp rise and fall. (Mode 1 at 4.1 amps and Mode 2 at 60 volts)

- I liked the other intensities better. This could be mistaken for an emergency vehicle or something. (Mode 1 at 4.1 amps and Mode 2 at 60 volts)

- The L-804s don't grab your attention. I could see your truck's parking lights better than the L-804s! You wouldn't notice the L-804s because you would be focused on following the centerline lights of the parallel taxiway. (Mode 1 at 4.1 amps and Mode 2 at 60 volts as seen from position P-1A)

FLASH RATE EVALUATION.

- This rate is slightly slow, but it gets your attention a little better. The 60 flashes per minute per lamp setting was too fast. (Mode 1 at 48 flashes per minute per lamp)

- If that is the change, then I don't like it. (Mode 1 at 30 flashes per minute per lamp)

- Too slow. (Mode 1 at 30 flashes per minute per lamp)

- This doesn't mean anything to me. I want to see something that says "STOP!" (Mode 1 at 30 flashes per minute per lamp)

RECOMMENDATIONS

Based on this evaluation, the following modifications to Advisory Circular 150/5345-46, Specifications for Runway and Taxiway Light Fixtures, are recommended:

1. Flash rate: 45-50 per minute per lamp.

2. Hoods are necessary.

3. Vertical aiming angle range should be +5° to +10°. The +15° vertical aiming angle setting would be unsatisfactory at the low observation heights encountered in smaller aircraft.

4. The face of the L-804 should be painted black.

5. The spacing between the L-804 lamps should be kept at 12 inches.

6. "Toe-in" of the L-804 units is not recommended. If the L-804 units are "toed-in" this could potentially become an annoyance to the pilots' eyes at night when the aircraft has stopped at or near the runway holding position.

7. Mounting height: 24 to 26 inches.

8. L-804 units should be installed on a dedicated L-804 circuit and not installed on taxiway or runway circuits.

9. Use multistep regulators to set L-804 intensities for day, night, instrument flight rules (IFR), and visual flight rules (VFR) conditions.